Chapter 7

Renewable Resources: Sun, Wind, Wood and Other Biofuels

Chapter 4 highlighted the use of fossil fuels. Fossil fuels are termed nonrenewable because they are in limited supply. This chapter will focus on resources that are readily available and *renewable*.

Renewable Energy

Renewable energy includes all of these forms of energy found on the planet — the sun, wind, wood and other biofuels. They make it possible to put the environment to work in positive ways. The use of renewable resources demonstrates energy technology at its creative best.

The Sun

The sun is the most powerful energy resource. It heats the planet and nourishes plants used for food. Without the sun, nothing could exist.

The energy from the sun is there for the taking. It is not only free, it never runs out. If all the sun's energy that falls on one square meter of the Earth's surface for one hour could be harnessed, a whole city could be lit for one year. Also, the energy from the sun poses no environmental hazards.

The Challenge of Tapping the Sun's Energy

With these many advantages, why is solar energy not being used to meet all of our energy needs? The answer is that tapping the sun's energy is not a straightforward process.

For maximum use of the sun, it must be constantly available. Yet, even under ideal weather conditions, the sun does not shine 24 hours a day, 365 days a year. To be useful, sunlight must be collected, moved to where it is needed and stored. This is no easy challenge.

People have been using the sun's energy for thousands of years for space and water heating purposes. With the beginning of the space age, scientists were able to develop a system that converts sunlight into electricity. This is called a photovoltaic system. Utilizing the sun's energy is categorized into four main systems: (1) active systems; (2) passive systems; (3) photovoltaic systems; and (4) hybrid systems.

The last, a hybrid system, is some combination of the other systems. In all of the systems, they must face the sun in order to work. For the northern hemisphere of the earth, where we live, the sun moves across the sky during the day from the southeast to the southwest. This creates the problem of where to face the system to get the maximum amount of energy from the sun. The answer is to position the system so that it faces due south, or only slightly east or west of south.

Active Solar Systems

Active solar systems use mechanical equipment such as pumps and fans to move energy around. There are two types of active systems; one is for space heating and the other is for water heating. A house using active space heating will have to face south, with most of its windows on the south wall. This allows winter sunlight to enter the house, thereby heating the air inside. This heated air is then circulated throughout the house by fans.

When sunlight passes through glass into an enclosed space, the wavelength of the light changes. This new wavelength can not pass back through the glass, thereby entrapping it in the house. This is known as the *greenhouse effect*. Think of it just like getting into the car on a cold winter day and finding the inside of the car warm.

More equipment needs to be added to the system if night time heating is necessary. The air is heated in collectors and circulated through a rock bed storage compartment. This is an insulated box which contains small rocks. These rocks are heated during the day, and at night, the air inside the home is circulated through the rock bed. As it passes through the rocks, it extracts the stored heat, and heated air is circulated back through the house.

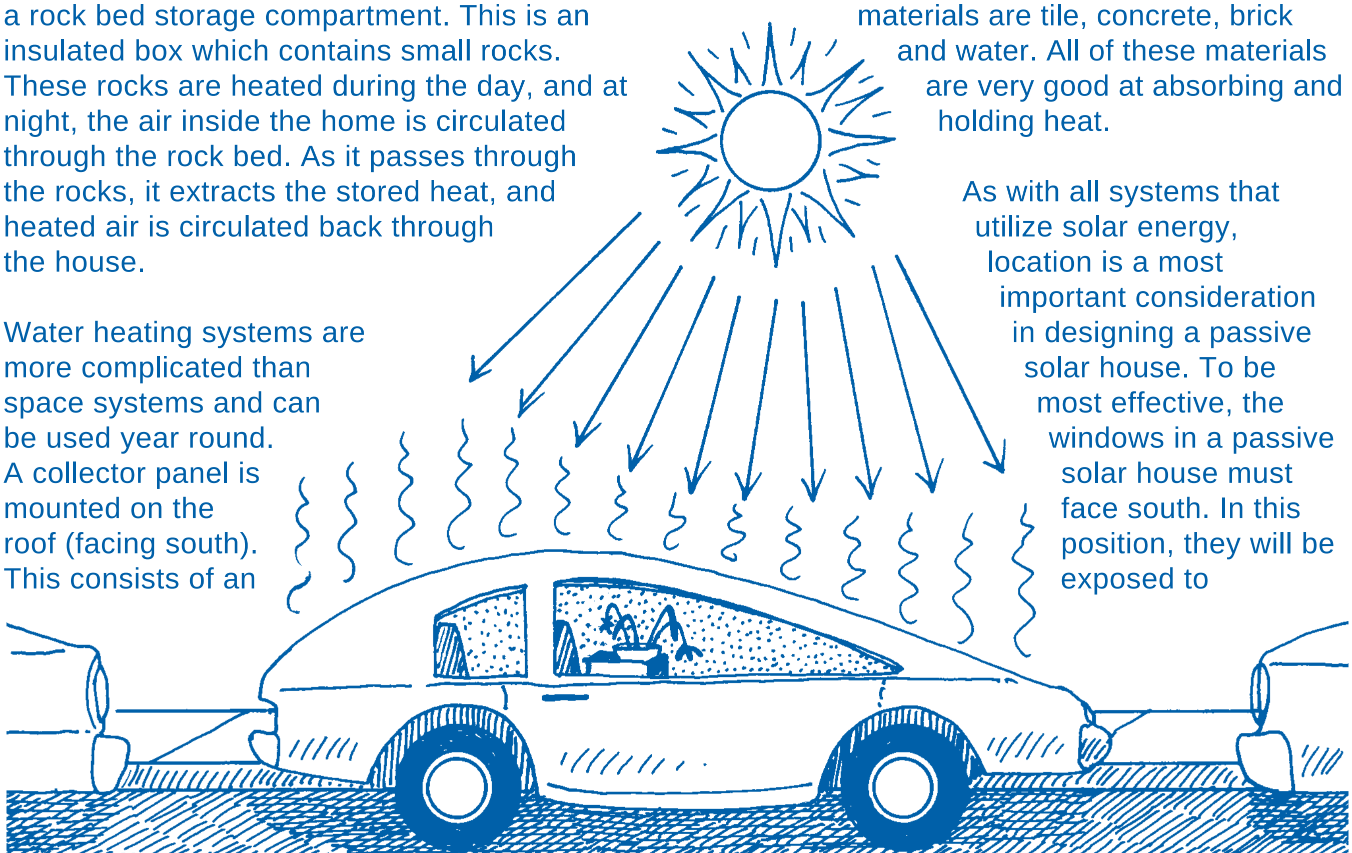
Water heating systems are more complicated than space systems and can be used year round. A collector panel is mounted on the roof (facing south). This consists of an insulated box with a clear glass or plastic cover. Inside this panel are many copper pipes and fins. These pipes are painted black to absorb and conduct the sun's heat to the water that is pumped through them.

This collector panel is attached to the water heater tank which is located inside the house. The water is circulated between the collector and the water tank by electric pumps. Cold water is pumped from the water tank to the collector and hot water is pumped back from the collector to the water tank. *Thermosensors*, which recognize changes in temperature, tell the pump when to turn on and off.

Passive Solar Systems

Passive solar systems do not use any mechanical equipment to move energy. In these systems, the actual building components become part of the system. These components, or thermal storage materials, are used to store heat during the day for use at night. Among the most commonly used thermal storage materials are tile, concrete, brick and water. All of these materials are very good at absorbing and holding heat.

As with all systems that utilize solar energy, location is a most important consideration in designing a passive solar house. To be most effective, the windows in a passive solar house must face south. In this position, they will be exposed to



The Greenhouse Effect

maximum sunlight. In addition, insulation should be placed around the glass to reduce heat loss. Windows, doors and walls need to be free of leaks so that trapped heat stays trapped.

Outside landscaping is another important part of passive solar systems. For example, evergreen trees that won't lose their leaves in winter can be planted on the north side of a home to provide winter wind protection. Trees that lose their leaves in winter can likewise be planted on the south side of a home to give it access to winter sunlight and to protect it from hot, summer sunshine.

Photovoltaic Solar Systems

Photovoltaic systems convert radiant energy from the sun into electricity. While photovoltaic technology has been around for 150 years, its actual commercial development did not occur until 1954. It was first used in 1958 to provide electric power for U.S. spacecraft and satellites.

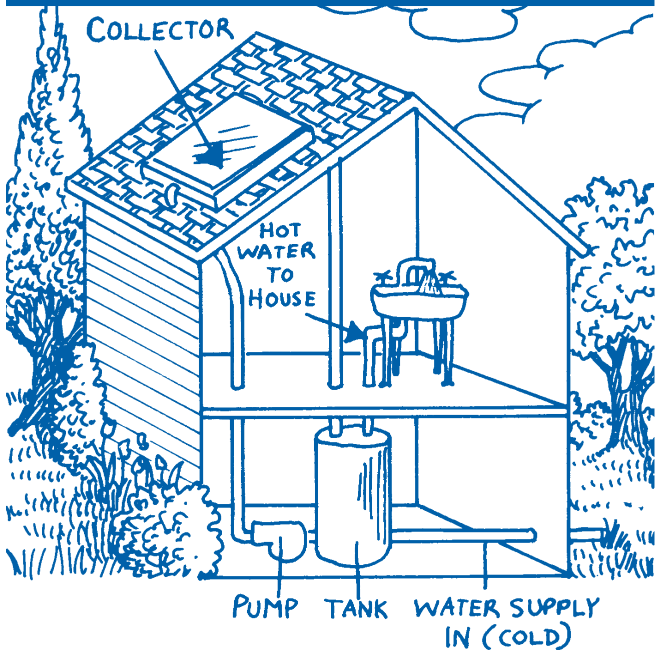
The cost of producing electricity through photovoltaic technology has dropped significantly in the past few years. Prices have gone from more than $50 per kilowatt to less than $0.30 per kilowatt. Photovoltaic systems, once seen as too expensive, are being used more frequently.

Photovoltaic systems are often used in remote areas where it is too expensive for power companies to bring in electric power lines. They also are being used to light road signs and power radio transmitters. Researchers developing electric cars also are making use of photovoltaic technology. Scientists at York Technical College in South Carolina, for example, are among those working hard to improve this technology.

Wood and Other Biofuels

Wood is one of the most plentiful forms of biomass (chemical potential energy) on the planet. More than 30 percent of the earth is covered by trees. Wood itself accounts for more than 80 percent of the biomass fuels used in the United States.

An Active Solar System



Wood was once the primary source of energy. From the time of the caveman it has been used as fuel. People learned that burning wood could be used to keep one another warm, to ward off animals, to light up the darkness and to cook food. Wood became the basis for early civilization.

Until the beginning of the previous century, wood's importance reigned supreme. As noted in Chapter 1, in the 1850s, 90 percent of all energy used in the United States was from wood. The Industrial Revolution was fueled by wood's energy. The commercial and residential sectors used wood for space heating, water heating and cooking. Fireplaces and wood stoves became familiar furnishings in most every home. Wood-powered steam locomotives and ships transported settlers across the country. Almost all aspects of everyday life was dependent on wood.

The use of fossil fuels as an energy source abruptly put an end to wood's popularity. The ease with which fossil fuels could be used made wood seem old fashioned. In South Carolina, dependence on wood lasted much longer than in many other parts of the country. Up until the 1960s, wood was one of South Carolina's primary fuels.

For about a decade following the Energy Crisis of 1973, it seemed that wood would make a comeback. However, once oil prices dropped, most Americans stopped using wood for everything except some space heating. In 1991, the U.S. Energy Information Administration reported that fuel wood use for water heating and cooking "has just about disappeared." This remains true today, as wood provides only three percent of the state's total energy needs.

The one economic sector that still makes use of wood energy is industry. The paper and lumber producing industries together account for almost all of the wood energy used today. Both of these industries use wood waste for steam, heat and to produce electricity.

Wood also can be used to make ethanol vehicle fuel, but the current process is quite expensive.

Biofuels have their origin in plants. During photosynthesis, the sun's energy is turned into biomass. Biomass can be used as it is, turned into a gas or processed into fuels such as methane, ethanol or methanol.

Energy from biomass is receiving much attention today. Though it accounts for only four percent of the energy used in the United States, it is an area with much potential.

Other Biofuels

Two other types of biomass have energy potential. These are *alcohol fuels* and *waste products*.

Alcohol fuels can be produced from crude oil, natural gas and coal. Through heating, methanol and ethanol are released. Methanol also can be obtained by gasifying wood. Ethanol can be made by *fermenting* corn or grains such as sorghum, barley and oats. Technologically, almost anything that grows can be used to make ethanol. Fermentation involves turning the starch in the corn or grains into sugar.

Methanol can be used as a transportation fuel. In fact, Henry Ford ran his Model T on methanol. Ethanol is frequently added to gasoline as an "extender." It also is blended with gasoline to form gasohol. In the 1970s, gasohol found short-lived fame as a gasoline substitute. Ethanol's future as a true substitute for gasoline is less certain these days. Right now, it is more costly to make than petroleum. However, federal tax benefits have kept development costs in check. If the price of corn (from which it is typically made) goes down and the price of crude oil (from which gasoline is made) goes up, ethanol is likely to become a more attractive alternative.

Waste Products

Organic Wastes

Organic wastes are usually divided into two categories — municipal waste and industrial waste. *Municipal wastes* includes household garbage and waste from office buildings, restaurants and supermarkets. *Industrial wastes* are the biological by-products produced by manufacturing. These include food, food processing remains and packaging material including paper, cardboard and straw.

Steam from Waste Incineration

Using municipal wastes for energy began in the 1980s as a response to the need for more landfills. Since trash is 75 percent burnable, landfill materials can be burned in specially designed incinerators. The produced heat is then converted into steam. Burning refuse not only creates steam energy, it reduces the volume of waste going to the landfill by 90 percent.

Industrial wastes are converted into wood fuel used for heating, electricity and the operation of industry. The pulp and paper companies, as described earlier, are the largest users of industrial waste energy.

In South Carolina, the largest user of municipal solid waste energy is the Foster Wheeler plant in Charleston (right). This plant produces steam and electricity by burning municipal solid waste.

Landfill Methane Gas

There are options for waste other than burning. Spartanburg's BMW automobile manufacturing facility has become the first direct use, non-utility company in South Carolina in more than two decades to recycle landfill methane gas as a source of energy. It is the only such facility now operating in the state.

Waste Management, Inc. (WMI), the largest waste handler and recycler in the world, supplies the methane gas from its Palmetto Landfill to Ameresco Energy Services. Ameresco cleans the methane, processes and compresses it, and delivers it nearly 10 miles to the BMW facility.

BMW has signed a 20-year purchase contract for the gas, and uses it to fuel four plant turbines. The turbines generate electricity and heat water, supplying about 20 percent of the facility's energy needs. This ultimately reduces the amount of fossil fuel burned at the 2.5 million square-foot facility and replaces it with a stable supply of renewable energy.

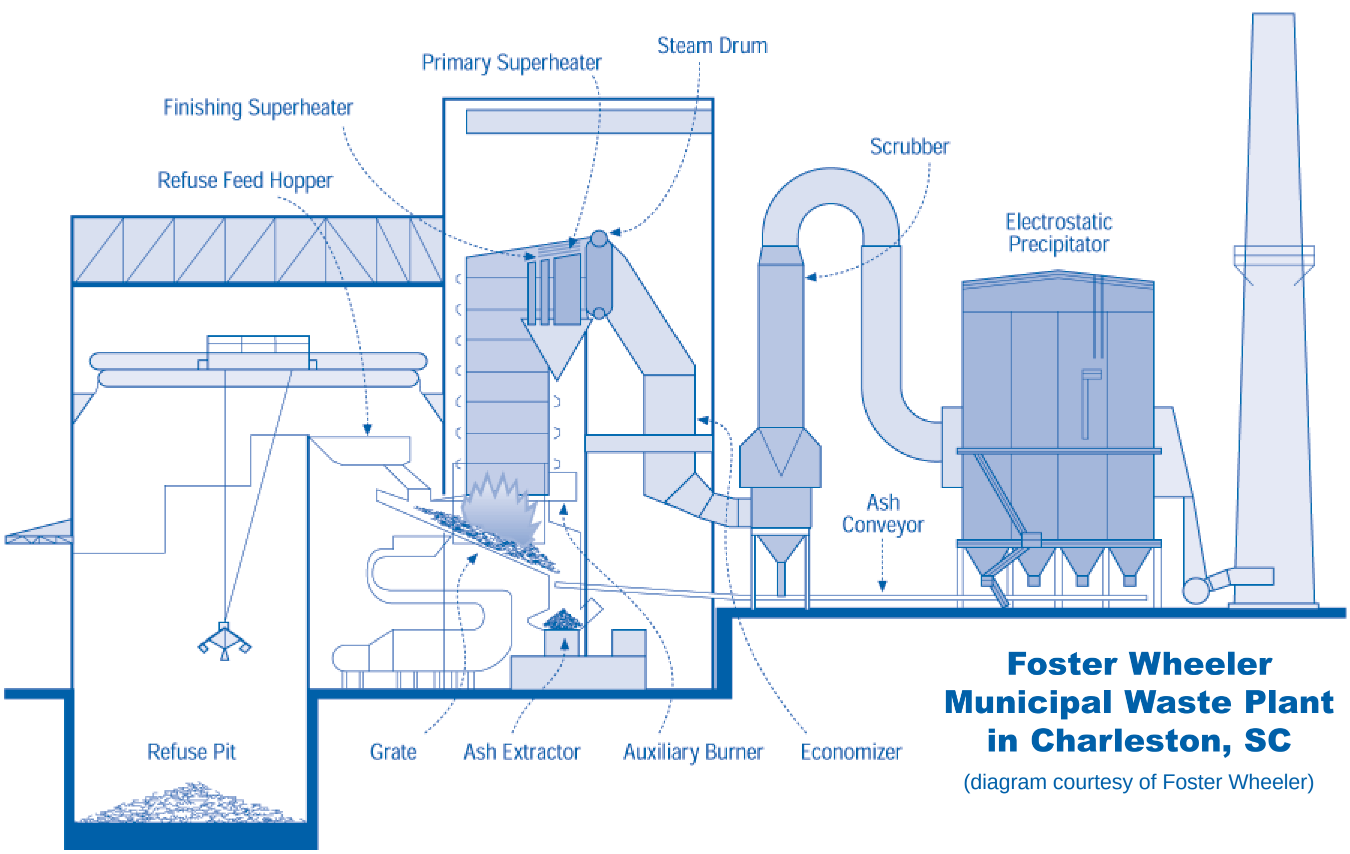
The project has an equivalency environmental benefit of removing 61,000 cars a year from the highways, every year, and an energy equivalency value of saving 80,000 to 100,000 barrels of crude oil each year the project is in operation.

An agreement was signed between the Lee County Landfill and Santee Cooper in 2003. The Lee County site will initially generate five megawatts, and eventually increase to about 12 megawatts. Santee Cooper will work with Black River Electric Cooperative to route electricity to the grid.

Animal and Human Wastes

One final group of waste products that need to be considered as potential energy sources are animal and human wastes. Referred to as agricultural waste and sewage sludge, these types of wastes have only recently been seriously considered for energy. Currently, no data is collected on their energy use, so it can only estimate how widely they are being used.

Animal waste (otherwise known as manure) is obtained from animals raised in confinement. This means that only a limited area needs to be



Foster Wheeler Municipal Waste Plant in Charleston, SC

(diagram courtesy of Foster Wheeler)

searched for collection. The droppings of dairy cattle, beef cattle, hogs and poultry are removed to covered ponds or vats known as *digester vessels*. Here, they are biologically converted into methane gas. The produced methane gas is used for space heating, as a boiler fuel or for generating electricity. Large dairy farms can use agricultural wastes collected on-site to fuel their own operations.

Human wastes also can be used for energy after being processed by public treatment facilities. Energy recovery processes, however, still are largely experimental. *Sludge*, made of water-logged solids formed when sewage is treated, can be burned or turned to methane.

Water treatment facilities are able to use sludge to fuel their operations. At present, however, technology only has been able to recover enough energy from sludge to supply about 34 percent of the energy needed to operate water treatment plants.

Wind

Wind is the reaction of the atmosphere to the earth's heating and cooling cycles. During the day, the sun's heat causes low pressure areas to form. At night, the loss of heat to space results in high pressure areas. When air flows from high pressure areas into low ones, wind is produced.

Using wind for energy is an idea almost as old as the wind itself. The ancient Egyptians used wind energy to sail to other ports-of-call. For hundreds of years, the Dutch and other Europeans built windmills to capture the wind's energy. Windmills captured the kinetic energy in wind and turned it into mechanical energy. The turning blades of the windmill were used to turn stones to grind grains.

In the United States, windmills have been used since pioneer times. Until the beginning of the 20th century, they were common fixtures in the Great Plains. Farmers used windmills to pump water. For many years, they also were used to generate electricity.

Today, wind power is again being used to make electricity. Modern windmills act as both turbines and generators, turning the wind's kinetic energy into electrical energy. At present, this way of making electricity is expensive and is viable only in certain geographical regions. To harness enough wind to make it effective, wind farms with hundreds of wind turbines would have to be built.

These operations not only take up great areas of land, but have other drawbacks, too. First, the wind is an unpredictable power source. It may dwindle to nothing or reach gale force with little warning. Large operations also are noisy and not very energy efficient.

Despite these drawbacks, engineers in Texas, California and Hawaii are succeeding in making wind-generated electricity cost-effective. Windmills in the ocean also are being considered. While wind has much potential as a clean source of electricity, it currently accounts for a small fraction of all electricity generated in the United States. South Carolina has few sustained winds and very little potential for ever using a significant amount of wind energy.

Conclusion

All of the renewable resources covered in this chapter hold great promise in the future. Even though wood and wind energy have been used since the dawn of civilization, they are being regarded in new, more efficient ways today. Scientists are hard at work determining how to make more effective use of all renewable resources.